YRKESHÖGSKOLAN
NOVIA

Last Planner® System

Investigation of Possible Benefits From Implementing LPS in Ruukki Construction Building Systems

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EXAMENSARBETE

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Abstrakt

Detta examensarbete är utfört på begäran av Ruukki Construction Building Systems. I detta arbete undersöker jag teorin bakom Last Planner System och dess eventuella lämplighet till nuvarande arbetsmetoder inom Ruukkis projektorganisationer. I samband med undersökningen görs även en kartläggning över utmaningar och återkommande problem genom projektens olika faser.

Undersökningen av teorin baserar sig på litteratur, rapporter och undersökningar. Genom intervjuer erhålls en helhetsbild över de i nuläget använda arbetsmetoderna. Intervjuerna görs med personer med ledande positioner inom Ruukkis projektledning, planering, tillverkning och montering. Problemkartläggningen baserar sig även på dessa intervjuer.

Resultatet utgör en tolkning vilken påvisar ifall Last Planner System kunde vara fördelaktigt för Ruukkis verksamhet. Resultatet innefattar även uppgjorda dokument-bottnar som är baserade på principer från Last Planner System. Dessa kommer fungera som hjälp för projektstyrning. Baserat på arbetet kommer jag framföra förbättringsförslag baserade på egna slutsatser utgående från teorin och intervjuerna. Problemkartläggningen kommer även att fungera som underlag för framtida utvekling.

Språk: Engelska Nyckelord: Last Planner System, Lean Construction, Produktionsstyrning

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Tiivistelmä

Tämä opinnäytetyö toteutetaan Ruukki Construction Building Systemin pyynnöstä. Opinnäytetyössäni tutkin teoriaa Last Planner menetelmän taustalla ja sen mahdollista soveltuvuutta Ruukin projektiorganisaatioiden nykyisiin toimintatapoihin. Tutkielman yhteydessä laaditaan kartoitus yleisimmästä haasteista ja toistuvista ongelmista projektien eri vaiheissa.

Teorian tutkimus perustuu kirjallisuuteen, raportteihin ja tutkimuksiin. Haastatteluilla luodaan kokonaiskuva nykyisistä toimintatavoista. Haastatteluja tehdään henkilöiden kanssa, jotka toimivat johtavissa asemissa Ruukin projektinhallinnassa, suunnittelussa, valmistuksessa ja asennuksessa. Ongelmien kartoitus perustuu näihin haastatteluihin.

Tulos on tulkinta joka osoittaa voiko Last Planner System olla hyödyksi Ruukin toiminnalle. Tulos sisältää myös valmiita dokumentti-pohjia jotka perustuvat Last Planner Systemin periaatteisiin. Nämä tulevat toimimaan apuna projektinohjauksessa. Tulen esittämään kehitysehdotuksia teorian, haastattelujen ja johtopäätöksien perusteella. Ongelmakartoitus tulee myös toimimaan alustana tulevassa kehityksessä.

Kieli: Englanti Avainsanat: Last Planner System, Lean Construction, Tuotannonohjaus

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BACHELOR'S THESIS

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Abstract

This thesis is written on behalf of Ruukki Construction Building Systems. In this thesis, I will be investigating the theory behind Last Planner System and its eventual suitability for Ruukki's current working methods within project organizations. Based on the investigation, I will expose and list challenges and recurring problems throughout the projects' different phases.

The theory part is based on literature, reports and surveys. An overview of the current working methods used will be gained by holding interviews. The interviews are held with people in leading positions from Ruukki's project management, design, production and installation.

The result comprises a conclusion whether Last Planner System would be beneficial for Ruukki's operations. The result also includes created document templates, based on Last Planner System. These documents are made to facilitate project management. Based on this thesis, I've made recommendations for future development based on my own conclusions taken from the theory and interviews. The list of problems created will also function as a base for future development.

Language: English Key words: Last Planner System, Lean Construction, Production Management

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1 Introduction

1.1 Purpose

The main purpose of this thesis is to find out what possible benefits Ruukki Construction Building Systems could gain from implementing Last Planner System principles. This requires theoretical research about Last Planner System and an investigation of the current situation regarding scheduling and steering project design, production and installation.

1.2 Case background

Last Planner System has in the last decade been implemented by many construction companies, which has resulted in great improvements in project productivity and predictability. The system has also entailed more profit for all stakeholders included in construction projects.

This system is run by the main-contractor on building sites, while Ruukki usually acts as a sub-contractor in projects. Ruukki's part in projects is usually substantial, and comprises own design, production and installation of steel structures. This requires good management and teamwork within the internal project organizations, as elements for projects can be manufactured in several different factories with every factory producing 10 different projects. Problems in one project will cause problems to all other projects that are being produced simultaneously. Sometimes projects face huge difficulties due to these abnormalities, which can cause a lot of extra costs and non-value adding processes. An implementation of Last Planner System principles could eventually enhance internal processes and make projects more productive and profitable.

1.3 Scope

A possible implementation of Last Planner System in Ruukki would mean a lot of work. My thesis has therefore been limited to investigating the principles and methods used in Last Planner System, and analysing the current way of working in Ruukki. The thesis will also include creation of document-templates for project management. A follow-up of an implementation has in other words been left outside the scope.

1.4 Goal and research methods

My goal is to by comparing LPS methods and Ruukki's own current working methods, conclude whether LPS would benefit Ruukki's operations. I will also present suggestions for development and create document templates for project management, based on Last Planner System principles. The investigation will also expose internal and external problems and challenges, which will be listed and work as a base for future development.

The research will be based on literature, reports, surveys and interviews. To get qualitative diversified answers, the interviews are done with different people in leading positions from Ruukki's project management, design, production and installation.

1.5 Client

Ruukki Construction has its origin from the Finnish company Rautaruukki, which was founded in Finland in the 1960's by the Finnish government to ensure raw material for the Finnish metal industry. The company has gone through several organizational changes through the years, and today Ruukki Construction is a subsidiary of SSAB, which is a Nordic and US-based steel company. They are operating globally with business in around 50 different countries.

Ruukki Construction manufacture and sell building and construction solutions with a focus on Northern- and Eastern European markets. The company is divided into four different business units: Building Systems, Building Components, Residential Roofing and Russia.

The company comprises around 2,500 employees and has 15 different plants and production facilities spread across Europe. The net sales 2016 amounted to 556 million euro. [1]

A brief explanation of the different business units:[2]

Building Systems:	*Construction contracting, including design, prefabrication and installation of steel structures for construction industry.*
Building Components:	*Manufactures sandwich-panels, façade products and load-bearing sheets.*

[1] https://www.ruukki.com/gbr/b2b/this-is-us
[2] Ruukki Construction intranet

Residential Roofing:	*Delivers steel roofs, rainwater systems, accessories and installation services.*
Russia:	*Entire portfolio from steel frames and sandwich panels to steel roofs and concept buildings.*

2 Theory

This chapter will comprise the theory behind Last Planner System. To understand the origin of LPS, one must know the ideas behind the Lean-philosophy. The construction industry differs in some ways from other manufacturing industries, and therefore it has got its own Lean-category which goes under the name Lean Construction. I will mention the ideas and principles of both Lean Production and Lean Construction and of course, Last Planner System.

2.1 Lean (Lean Production)

The word Lean or Lean Production has its origin from Toyotas developing strategy Toyota Production system. The main concepts that described their strategy are: JIT (just-in-time) -processes, Jidoka and Continual Improvement[3] (kaizen). JIT means that every process should produce only as much as needed to continue with the next process, to minimize waste. Jidoka is the Japanese term for "Intelligent automation" or "Automation with a human touch".[4] It basically means that machines and production will stop when errors occur and correct them, instead of continue producing non-value products. The "kaizen-philosophy" means that employees are proactively working together from all levels to achieve continual improvements to the manufacturing process.[5]

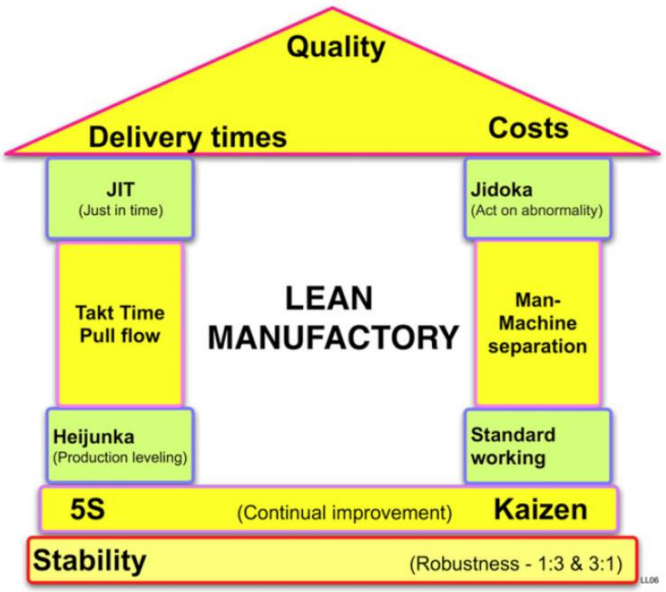

Figure 1 The Lean Pyramid

[3] Lecture in LC, Novia Oct 2017
[4] https://web.archive.org/web/20110714222919/http://www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20021209&1&
[5] https://www.leanproduction.com/kaizen.html

One crucial component of Lean is eliminating all non-value adding processes or wastes[6] when it comes to material, working hours and the amount of effort put into production. These wastes are listed below:

1. Overproduction – *Produce more than needed (over quality)*
2. Waiting – *Waiting for something to happen, waiting for others to finish*
3. Storage – *Unneeded storage*
4. Movement – *Unnecessary movement of workforce and materials*
5. Redo – *Repairs, corrections*
6. Overtime – *Do more job than customer demands*
7. Transports – *Unnecessary transports*
8. Not taking advantage of co-workers creativity

Another integral part of Lean is 5S, which is a philosophy of optimized use of work space with tidiness and by sorting equipment, tools and material to achieve maximum efficiency/m^2 and to increase workspace safety.[7]

Figure 2 The components of 5S

[6] Porwal V., 2014, P. 1
[7] https://www.5stoday.com/what-is-5s/

Lean Construction comprises the same philosophy and ideas as Lean production. A substantial part of the construction business is project-oriented and it might be complicated implementing Lean Production ideas, as it suits serial and manufacturing industries better. Therefore, this branch has developed its own Lean-category.

2.2 Lean Construction

The construction industry is very conservative and over the last 50 years, when other industries have increased their productivity, the construction industry has seen a decline in productivity. The industry suffers from huge amounts of non-value adding processes. As shown in figure 1 below, the amount of non-value adding processes (waste) in the construction industry are much higher than in manufacturing industry. Safety is also a big issue and the industry still suffers many fatal accidents[8]. In Europe alone, the construction industry represents over 20% of all fatal work related accidents.[9]

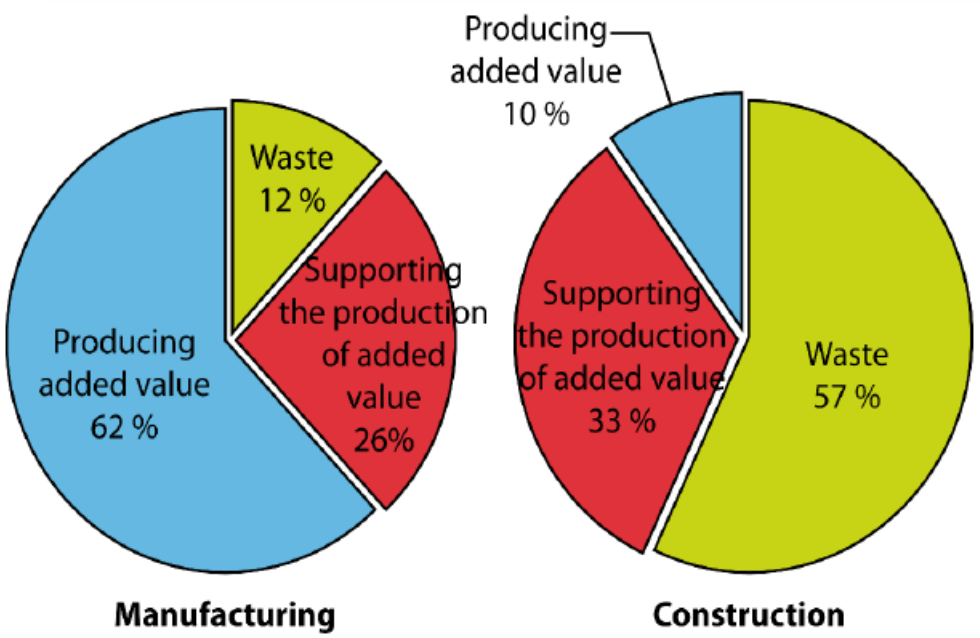

Figure 3 Differences between manufacturing and construction industry

[8] https://www.youtube.com/watch?v=3pmwaGuAQgM
[9] Eurostat, Statistical office of European Union

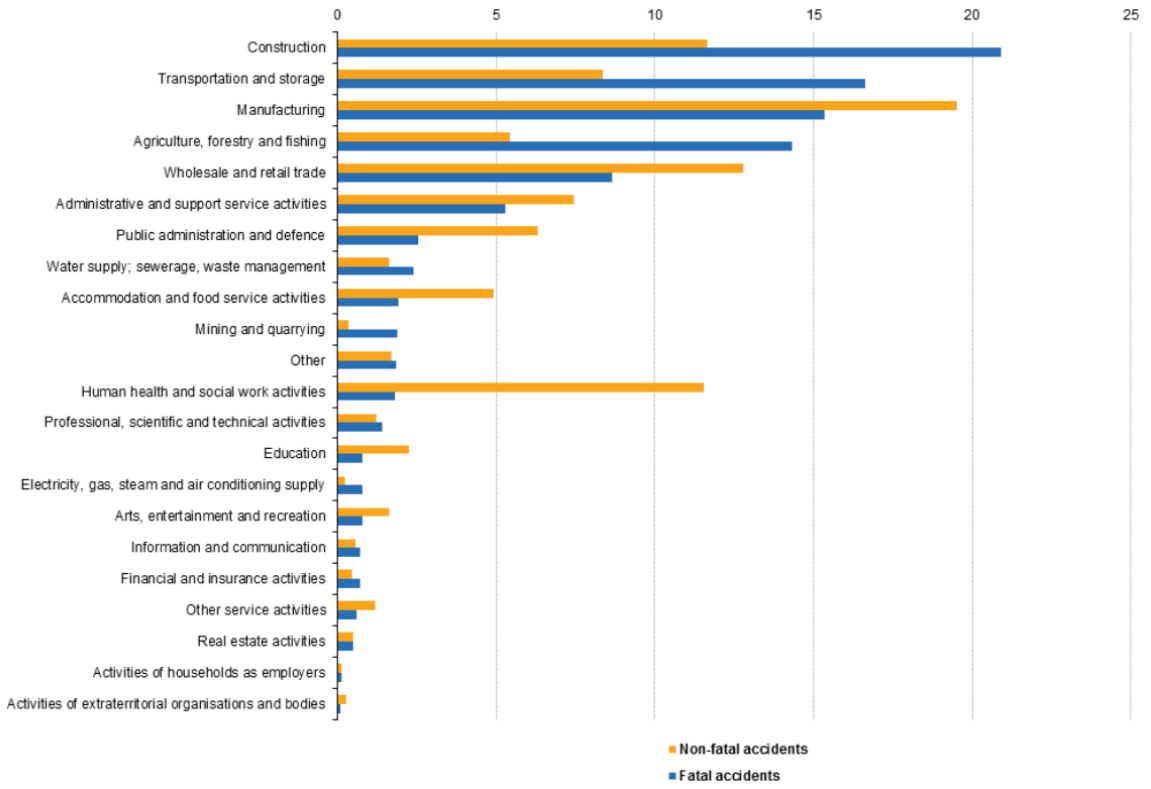

Figure 4 Percentage of fatal and non-fatal work related accidents by economic activity in EU (2014)

Project based businesses are very vulnerable to unexpected changes, and deviations may cause additional costs and delays for projects. Especially construction projects are very vulnerable as they often are one-of-a-kind projects with a minimum rage of standardized components. In addition, these projects are often undertaken in an open environment, contrary to the controlled setting of serial manufacturing. [10]

The main principle of Lean Construction is not to work harder but to work smarter. Through better planning, correct materials, tools, locations and right quantities, higher efficiency will be gained. To achieve good results, it is essential to strive towards collaboration, teamwork, and involving everybody in improving and developing the different phases throughout the production. Team building and focusing on people may be the most essential parts in Lean Construction.[10]

[10] Lecture in LC, Novia Oct 2017

The six tenets of Lean Construction are: continuous improvement, generation of value, focus on process and flow, removal of waste, optimizing the whole and respect for people.[8]

Figure 5 The six tenets of Lean Construction

Tools and principles from Lean Production are also used in the construction industry, but there are other tools like BIM (Building Information Modelling) and Last Planner System that has been made to serve the special needs that defines the construction industry.[10]

BIM is a 3D-model based process that gives all parties from the construction industry (architects, engineers, designers, constructors etc.) an insight in projects and common tools that enable efficient planning, designing, constructing and project steering in building -and infrastructure projects. [11]

Lean Construction Institute, LCI

LCI is an international non-profit organization with national communities in Canada, Russia, Israel, Great Britain, Ireland, Denmark, Germany, Norway, Finland and Australia. These organizations are working together and sharing information in order to develop the construction industry. Furthermore, LCI is also doing research in lean construction and publish reports and articles regarding the subject. They also arrange events and workshops and hold an annual LCI Congress.

[11] https://www.autodesk.com/solutions/bim

The national communities each have their own web-sites where they post the latest news in Lean and the construction industry. Here articles regarding companies implementing lean and LPS in their operations can be found.

Contacting LCI when implementing Lean construction can prove beneficial, as the people working there are professionals and have substantial knowledge and experience from previous projects and implementation processes. [12]

2.3 Last Planner System

Last Planner System (LPS) is a production planning and controlling system designed for the construction industry[13]. It's not a software program or a particular tool you can buy and start using right away. LPS is a way of working including numerous procedures and routines to be carried out in order successfully implement it into a company's own planning and monitoring processes.

LPS is one of the most essential parts in Lean Construction, but in a report written by Alan Moss, Moss claims that Lean Construction is much more than just LPS [14] and to successfully implement LPS, the company should have a Lean-mindset as well.

The name "Last Planner ", describes one of the main points in LPS. Last Planner refers to the person, the actual executor or its representative in the project (The one who actually knows what's needed for a task to be completed and how long it will take). It can be a worker or its foreman.[15]

As collaboration is crucial in LPS, focus is being put on people and team building. To get everyone involved, understanding and knowing what's being done, where we are, who's doing what, where we are going and when we should be finished, LPS aims for making plans and schedules as visual as possible for everyone. [15]

The goal is to by proper planning make sure all preconditions of activities exist so they can be carried out without any disturbances from preceding or ongoing work activities. [16]

[12] https://www.leanconstruction.org/
[13] Porwal V., 2014, P.1
[14] Mossman A., 2013, P. 26
[15] Lecture in LC, Novia Oct 2017
[16] Koskela & Koskenvesa 2003, P. 5

During the 90's in the USA, studies showed that even with well managed sites with competent engineers and managers, 50% of the projects weren't able to deliver tasks in the week that were supposed to be delivered. [17] In order to solve the problems with the production flows, Ballard and Howell (1997) designed a planning and controlling system and named it Last Planner System[18]. It was made of constructors for constructors in order to get more predictable and reliable schedules. The Lean Construction Institute describes last planner like this:

"LPS is the collaborative, commitment-based planning system that integrates should-can-will-did planning: pull planning, make-ready look-ahead planning with constraint analysis, weekly work planning based upon reliable promises, and learning based upon analysis of PPC and Reasons for Variance."[19]

The main principles of LPS are as follows:[20]

1. Detailed planning
2. Produce plans collaboratively with the "Last Planners" (the executors)
3. Reveal and remove constraints
4. Make realistic, reliable promises and secure them
5. Learning from previous breakdowns

2.3.1 Last Planner in practice

When people hear Last Planner the first thing that comes to mind might be people gathered in a room attaching colourful post-it-stickers on a timeline. That's maybe the most essential one but not the only phase in the system. LPS includes a number of processes that are carried out in different phases. There are five main functions in LPS. The whole system is based on collaboration in form of meetings and discussions, which are usually led by the project manager or main contractor's site manager.

[17] Koskela & Koskenvesa 2003, P. 14
[18] Porwal V., 2014, P.1
[19] https://www.leanconstruction.org/learning/education/glossary/
[20] Porwal V., 2014, P.9

The different functions or phases in the process are listed below. [21]

1. **Collaborative Planning** – Creating and agreeing on the production sequence (and compressed if required)

2. **Make Ready** – Making tasks in the *Look Ahead* period ready (i.e. constraint free, clarifying all preconditions exist)

3. **Production Planning** – Collaboratively agreeing production tasks for the next day or week

4. **Production Management** – Collaboratively monitoring production to keep activities on track

5. **Measurement, learning and continual improvement** – Learning together and improving project-, planning- and production processes

All functions include different components/techniques and metrics for measurement to help steering the processes.

These functions are listed in the order they are performed. Feedback loops can be made after measuring and learning from previous production sequences as shown in the picture below.

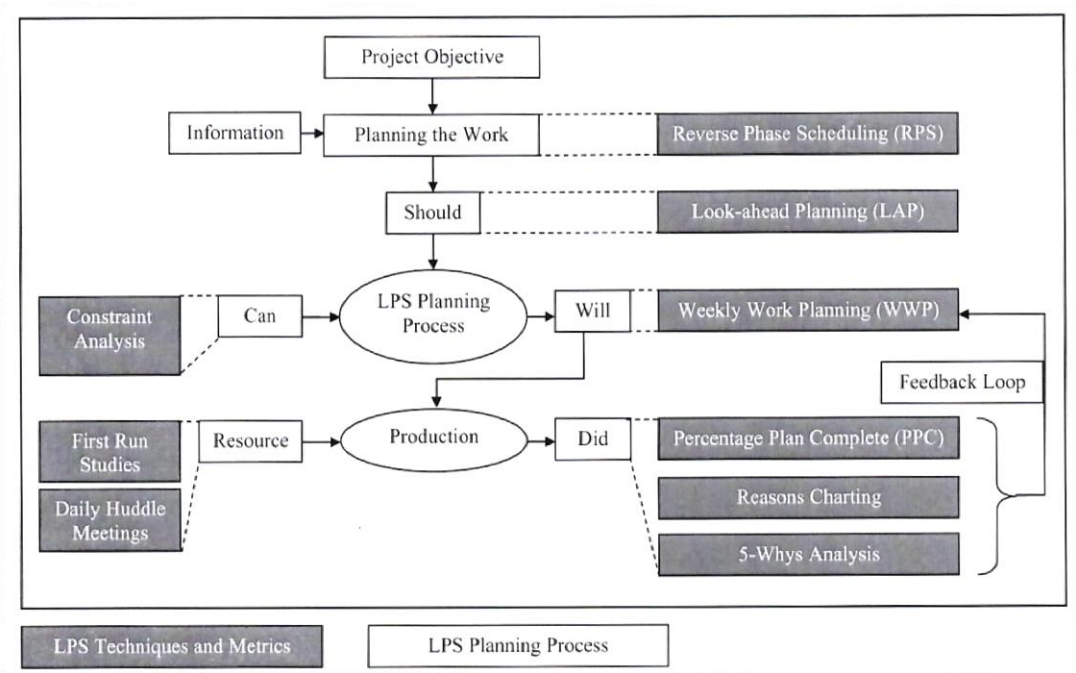

Figure 6 LPS planning process and its components

[21] Mossman A., 2013, P.11

2.3.1.1 Collaborating Programming

This phase could be called start up meeting where all parties come together and discuss the case, vision and goals (*what should be done*). The end-users requirements are discussed and critical interdependencies are gone through. One of the most integral parts is the risk assessment. This has to be carefully gone through so that everyone involved knows what the potential risks are. It's also an opportunity to share own risk-notices. Eliminating risks in an early phase, allows the project to progress according to plan. [22]

During this phase, a master schedule with production milestones should be created and agreed on between parties. A phase schedule can be created instead of the master schedule if the project is big or complex. Methods like phase scheduling and big-room meetings with post-it sticker scheduling are used here.

Phase scheduling, is a technique where the team defines milestones and production phases, breaks down the phases into activities and schedules the activities backwards from defined production milestones. [23]

Post-it sticker scheduling might be the part that distinguishes LPS. When last planners are gathered together in the big-room, every last planner places, one at the time, stickers with their own colour on the schedule-wall. The colour represents the construction sequence or activities (basically the contractor executing the activity) and is used to make the entirety of the schedule more visually understandable.

When all planners have placed their post-its, discussion is held to make sure everything is in order. After this everyone is asked to make a promise of commitment to the plan. Committing promises face to face with many people in the same room has a psychological effect which usually makes people keep their promises. It's easier to neglect promises if you don't have to meet the people. [24]

When the schedule is done, it can be transferred into digital form using a Last Planner software or e.g. Excel.

[22] Mossman A., 2013, P.13
[23] Porwal V., 2014, P.10
[24] Lecture in LC, Novia Oct 2017

Figure 7 Production planning with Last Planners

The end result of these discussions should result in: [25]

- **Work plan** - what should be done
- **Organization chart** - showing who does what
- **Agreement between parties involved** - start and finish dates (schedule)
- **Logistic plan** - when, loading area, safety etc.
- **Workflow control tool –** can be software or whole-wall schedule with Post-its.

The benefits from this phase are that it prepares the team for collaborating with each other and makes the time plan more predictable.

2.3.1.2 Make Ready

In this phase pre-conditions for putting work in action are ensured. Look-ahead planning means preparing in advance so things can be done when they need to be done. According to Koskela, there are seven streams in a construction project that have to be fulfilled before putting anything to production. [26]

Seven streams: *People, Information, Equipment, Materials, Prior work, Safe external conditions* and *Safe space.*

This method can easily be used and followed up through an excel-sheet or checklist-document.

[25] Mossman A., 2013, P. 12-13
[26] Koskela L., 2000, P. 187-188

MakeReady: Assembly — company: M-hill Groundworks Ltd

project: Waitrose Droitwich — contracts manager: Ted Foster 0121 796 8485; 07731 252730

phase: foundations & shell — prepared by: **Jim Jones 07968 485 627**

area: — date prepared: Weds 8 October 2008

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ref	task description	program start date	responsible party	Information: contract/ instr.	Information: design	Information: RFIs	Information: mthd stmt	Pre-req: wea-ther	Pre-req: tasks	Resources: plant	Resources: labour	Resources: space	Resources: materials	can do	notes
1	drainage - exg foul manhole to FMH11	28 Oct	M-hill	✔	✔	✔		✔	✔	✔	✔	✔	✔		method statement - induction
2	reinforcement to toe D2-F2 (incl DL & DLB)	28 Oct	M-hill	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
3	drainage access MH & stanchion base deepening & ducts	29 Oct	M-hill	✔	✔	97	✔	✔	✔	✔	✔	✔	✔		RFI97

Figure 8 Example of Make-ready checklist based on the idea of "seven streams"

The Constraint-log is another useful tool. Constraints are listed and an action plan for how to deal with them is written down. This log also shows who's responsible for eliminating constraints. This enables managers to act with a proactive approach rather than with a reactive. Using this it's easier to avoid surprises.[27]

2.3.1.3 Production Planning

Production planning means all last planners involved come together in weekly meetings, PEP-meetings (Production, Evaluation & Planning) that usually lasts for about an hour. These can also be called ***Weekly Work Planning***. Planners make up schedules for the next period (usually 1-5 weeks depending on size of project) and go through *what has been done, what's being done* and *what should be done.* Reviewing and learning from the previous period helps improving the upcoming workweeks. Commitment based post-it scheduling is used here as well. [28]

Figure 9 Weekly Work Planning meeting in action.

[27] Lecture in LC, Novia Oct 2017
[28] Mossman A., 2013, P. 16-17

2.3.1.4 Production Management

This phase connotes managing and controlling progress and workflow. There's many ways of doing this. Doing it according to LPS, means collaboration through short discussions with installation teams and other contractors. A short telephone conference with other managers can also be a daily routine to keep everyone on track.[29]

Daily Huddle Meetings are also held to give the project organization and installation team members a daily status update on what has been done since the previous day and what's being done the same day.[30]

Figure 10 Daily huddle with the installation team

2.3.1.5 Measurement, learning and continual improvement

Before an upcoming PEP-meeting, each contractor evaluates and makes a review of the work done from previous week. Here a measurement called PPC (Percentage Plan Completed) is useful. It can also be called POC (Percentage of Completion).

Percentage Plan Completed shows if teams could complete all tasks promised within a given timeframe. The goal is of course to get as high PPC-rate as possible and continuously strive towards 100 percent. This is of course hard due to uncertainties. After calculating the PPC which is done by dividing completed tasks with promised tasks, causes for uncompleted tasks are resolved and discussed.[31]

[29] Mossman A., 2013, P. 18
[30] Porwal V., 2014, P. 12
[31] Mossman A., 2013, P. 18-19

The PPC is a quite useful tool as it clearly shows contractors' or team's productivity and ability to fulfil their promises. If a contractors PPC continuously indicates low completion rates, changes must be made within the own organization in order to get higher PPC-rates. Sometimes the reason can be the last planner's tendency not to say "*no"* or *"I don't know".*[32] The LPS won't work if planners can't rely on one planner's promises. It's relevant that discussions are held when uncertainties occur and that people are humble when dealing with problems.

The teams make a progress evaluation of their own work, which they present on the next upcoming PEP-meeting. During the meeting discussions are held and changes in the schedule can be made according to learnings from previous period.

First Run Studies is a technique that can be used when problems and constraints start appearing continuously. First run studies mean you go deeper in finding the origin of the problem by analysing all steps in the activity. This might mean changes and redesigning critical sequences in the production.[33]

5 x Whys-method is a method that helps finding the root cause to problems. Here you simply ask why to the previous answer 5 times in order to find the root cause of the problem. [34]

When the issues are solved, an acting plan is made, carried out and monitored to see if the new plan is working. Figure 6 shows the connection between First Run Studies and the other phases in the planning and controlling process.

2.3.2 Tools and software

There are not many tools or software made especially for LPS. Companies usually create their own documents, templates, check-lists and schedules with what suites them best.

OurPlan is a web-based software that works as a visual planning tool for helping managers and foremen managing LPS. Commitments and time schedules are visible in this software and as it is web-based; all team members can log in and take part of the information there.[35]

[32] Mossman A., 2013, P. 17
[33] Porwal V., 2014, P. 12-13
[34] Porwal V., 2014, P. 15
[35] https://constructech.com/ourplan/

ProjectFlow (SPS) and Lean Planner[36] (by Newforma) are other software programs that can be used for the same purpose as ourPlan and works in a similar way.

Figure 11 Planning and monitoring with Lean Planner (Newforma)

[36] https://www.youtube.com/watch?v=mBh1A_Sc3rw

2.4 Why Last Planner

What are the most prominent improvements with implementing Last Planner? There are several advantages, and listed below are some of the most prominent improvements companies have gained after implementing LPS. The chapter also includes challenges companies have faced during their implementation of LPS. The data is taken from different reports, surveys and literature.

2.4.1 Benefits according to surveys and reports

Reliable time schedules

In general when creating time schedules the length of different activities are based on assumptions and guesses. According to Mossman, the traditional Critical Path Method (CPM) can be considered as a wish-list rather than a reliable time schedule. In the CPM, teams test if they have the capacity to complete tasks in a given timeframe.[37] Using the traditional way of planning sometimes forces the planner (in this case the "first planner") to add buffers in the schedules. When consulting sub-contractors they do the same due to uncertainty. This may lead to an uneven work flow where some activities are waiting though they're ready to be initiated, and the other way around. In LPS all activities are gone through with the whole team and decisions are made by the people who actually know how long their activities last. [38]

Notice problems early

Usually in projects, managers try to catch things after they've gone wrong. With LPS and the *Look Ahead Planning*, you eliminate these risks with good planning and preparations. Making sure things can be done when they need to be done gives you a chance to notice constraints and makes production control more pro-active rather than reactive. Collaboration and in-advance planning helps you spot conflicting objectives such as overlap-working between contractors. In this manner, LPS prevents fire-fighting problems as they are noticed before they occur. "Bad news early, are good news". [39]

[37] Mossman A., 2013, P. 8
[38] Mossman A., 2013, P. 12
[39] Mossman A., 2013, P. 4

Increased productivity

LPS reduces waiting as parties in the project systematically are ensuring previous tasks are completed and all necessities needed for the following ones are in place. Waiting is one of the most common wastes as nothing is being produced while costs are running. Follow-on teams are prevented from starting when others are late. The workflow ceases and the project is basically bleeding money. All delays cause irritation which harms the team-spirit.[40]

LPS also reduces stress on staff. When all management and supervisory staff are planning the work together, responsibilities are distributed among the personnel. This gives everyone a common vision and direction of the project and reduces the load for the individual. Accordingly, stress from unexpected events and fire-fighting can be avoided. [41]

Reduces costs

The Danish contracting firm MT Højgaard made a survey after implementing LC and LPS in their system. Survey shows that projects with LPS were 25% more profitable than others. It also showed that even sub-contractors had better profit in these projects. One thing they consider is, surprisingly, that administrative cost for project managing has only increased by 0.1 % even though they've added new functions and staff. The reason, they claim, is that "some of the traditional managerial roles on the building site may turn out to be obsolete". The total cost is still reduced, as extra costs for project management prevents fire-fighting that tend to cause a lot of costs in the projects finishing phase. [42]

Increases safety

When everybody is involved in the planning, everyone knows what is being done and where. This ensures no overlapping work that could lead to potential safety risks. When sharing information, lack in safety and other obstacles are made visible and dealt with right away. In MT Højgaards survey, results show that number of accidents decreased by around 50% and absence due to sick leave also decreased by 40%. [43]

[40] Mossman A., 2013, P. 4
[41] Mossman A., 2013, P. 7
[42] Thomassen Sander Barnes Nielsen (2003), P. 5-7 & 10
[43] Thomassen Sander Barnes Nielsen (2003), P. 8-10

2.4.2 Challenges according to surveys and reports

Commitment and partial implementation

Implementation requires a very active role from everybody in the project organization. Leadership and good management plays a key role in order to succeed. It's important to carry out all different components of LPS. According to studies of 77 Chilean construction projects, studies showed that projects with more complete implementation including all components had higher PPC rate than other projects with partial or intermittent implementation.

In Germany where LPS is seen as the leading concept of Lean Construction, companies have partially implemented LPS components, showing it's possible. Though they claim they function better when applying them together. [44]

Attitude

Implementation of new systems and programs might be difficult as there's always people who are resistant to changes and new ideas. In LPS these can be, for example, refusal of commitments, refusal to include sub-contractors in meetings and negative attitudes towards different components in the LPS system. [45]

Lack of time for activities and learning

In a Chilean project, time needed for training, meetings and preparations exceeded the capacity of the project personnel. Introducing lean concepts and teaching the different techniques are time consuming. [46]

Misinterpretation of 5-whys' analysis

Using 5-whys for evaluating one's work can sometimes create barriers in the project organization as evaluation in some cases can be interpreted as being accused for not being able to complete promised tasks.[47]

[44] Porwal V., 2014, P.22-24
[45] Porwal V., 2014, P. 26
[46] Porwal V., 2014, P. 25
[47] Pakka J., 2010, P. 24-29

Contractual issues

Traditional contracts between main contractors and sub-contractors are defined with specified conditions, demands and obligations. Extent of work and work boundaries are defined as well. As collaboration between trades is a crucial point in LPS, having traditional contracts might cause problems and allow sub-contractors to only care for their own work within the defined contractual boundaries. This results in contractors neglecting other contractors work and the total outcome of the project. This so called "fishing for profit" between trades often results in conflicts and usually ends with less profit for everyone involved. [48]

Making or finding suitable contracts for this can be challenging. There is a quite new form of contract named Integrated Form of Agreement (IFOA)[49] where parties (client, designer, contractor and other trade partners) are bound to a single agreement which requires them to share risks and rewards.[50] In Finland this agreement has been used on several massive construction projects with great results where the projects have finished within schedule and budget. [48]

[48] Lecture in LC, Novia Oct 2017
[49] In Finnish: Allianssi-Malli
[50] Porwal V., 2014, P. 27

3 Current situation in Ruukki Construction Building Systems

3.1 Project planning and monitoring

Projects include different phases like design, production and installation. All these depend on each other, which mean that reliable project plans are essential in order to be able to deliver elements on time. In Ruukki, reliability is of high importance as there might be several factories where columns and beams for ten different projects are being produced simultaneously. This chapter describes organization structures and how they work when making plans.

3.1.1 Company & Project organization

Ruukki Construction Building Systems is divided into different business areas: single-storey buildings, multi-storey buildings, heavy industry and bridges. Each business area is dealing with one specific type of projects and has its own business area manager and project managers. The project managers carry the main responsibility for their own project(s) and report to the business area manager. Each project has its own project organization including project manager, site manager, design manager and project engineer. Depending on size, or the scope of the project, the project organization set up may vary. [51]

In bigger projects with in-house design and production in many different factories, controlling and steering can be challenging in order to keep everything on track. Well-working communication between customer, design, factory and site is crucial to keep control over projects.

In the figure below, is shown how the basic project organisation matrix usually looks like.

[51] Discussion 28.11.2017

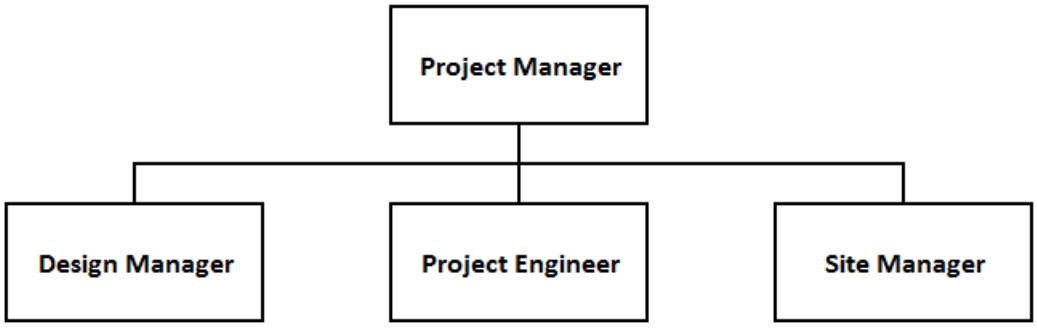

Figure 12 The most common project organization set-up in Ruukki Construction Building System

3.1.2 Planning & scheduling

One of the most essentials plans in projects is the time schedule. The so called master schedule covers the time lapse from start to end in the process including design, manufacturing and installation. All activities throughout the project rely on the master schedule. This means that changes in the master schedule affects everyone in the project organization. [52]

There are no specific guidelines or given instructions on how to operate when making plans and schedules. It's up to the project manager and other members in the project organization to choose how they work and with whom. There is though, a logical order in which things are usually done.

Scheduling comes in a very early phase of the project. Already during the offering phase preliminary master schedules are made. The master schedule is based on the date the customer wish to have first delivery of elements to the building site. The schedule is then counted backwards from the delivery date and time needed is estimated in a preliminary master schedule. The preliminary master schedule is made by the salesperson who then can ask for comments or opinions from the business area manager, project manager or from the factories. If no comments are given, the deal is signed with the customer based on the preliminary master schedule.[53]

When start and finish dates are known the Project Manager (PM) and the Business Area Manager (BAM) create the actual master schedule where the projects different phases are

[52] Discussion 28.11.2017
[53] Discussion 24.11.2017

more carefully planned. When own design is a big part of the scope a Design Manager (DM) usually participates during scheduling. The master schedule is then shared with the rest of the project organization. [54]

When the rest of the project organization has taken part of the master schedule, more detailed schedules for installation, design and production can be made by those responsible for each field. The production schedules are based on the delivery sequence and master schedule.

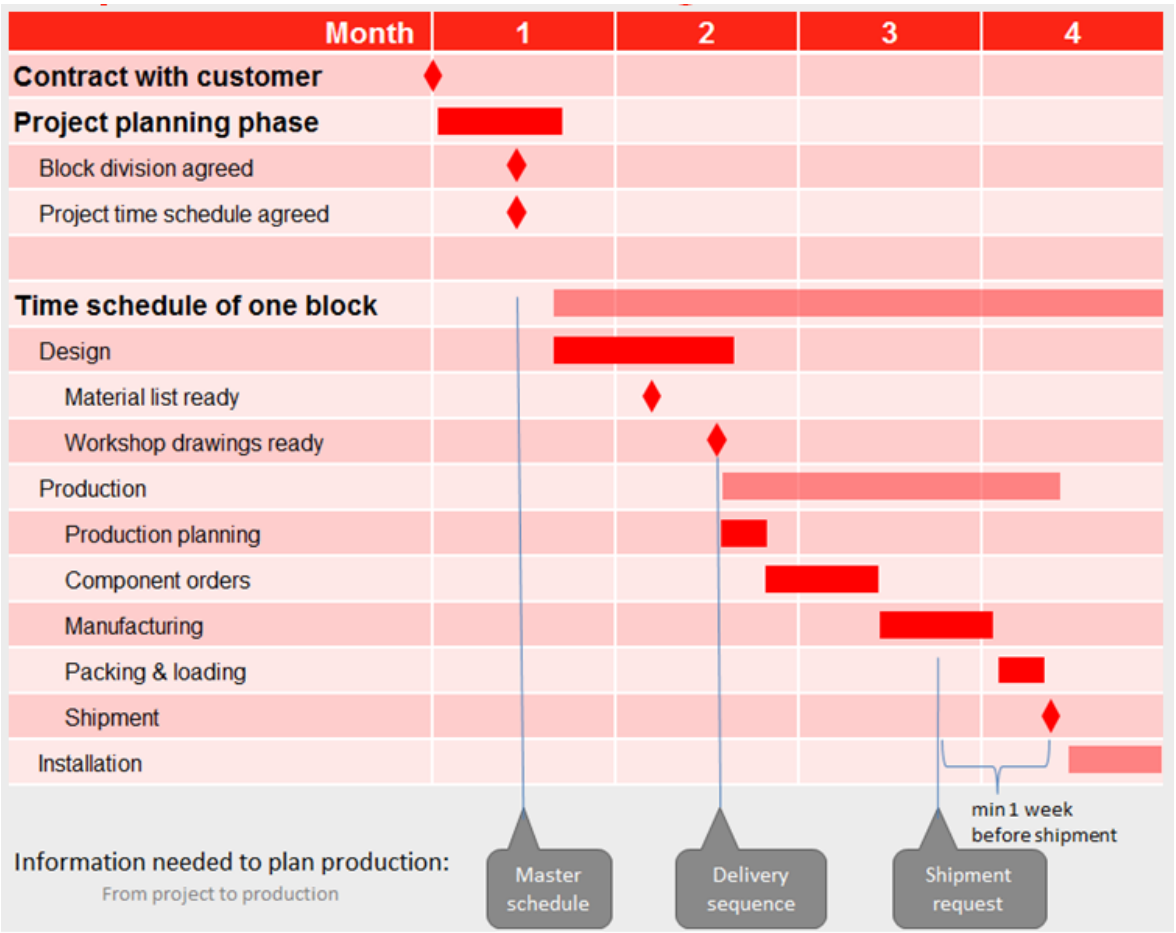

Figure 13 Simplified project schedule for one block

3.1.3 Monitoring and controlling

It is the project manager who is monitoring the total progress of the project. Activities on site and factories are monitored by site manager and project engineers who then reports to the project manager.

[54] Discussion 28.11.2017

On site there is no common way or specific instructions on how to monitor or to do follow-ups. Site managers and foremen use their own methods to keep to the schedule. As Ruukki mostly operates in the form of sub-contractor, collaboration with the main contractor regarding monitoring and scheduling is essential. [55]

In factories, weekly progress meeting are held to keep everyone on track on what is being produced and when. These meetings show the factories' workload and used capacity.[56]

Tools like Tekla and SAP are being used for follow-ups. These tools provide an overview regarding costs and production- and installation progress.

In the Tekla-model below, the different colours represent status of each element. This is a very visual tool and helpful when doing follow-ups.

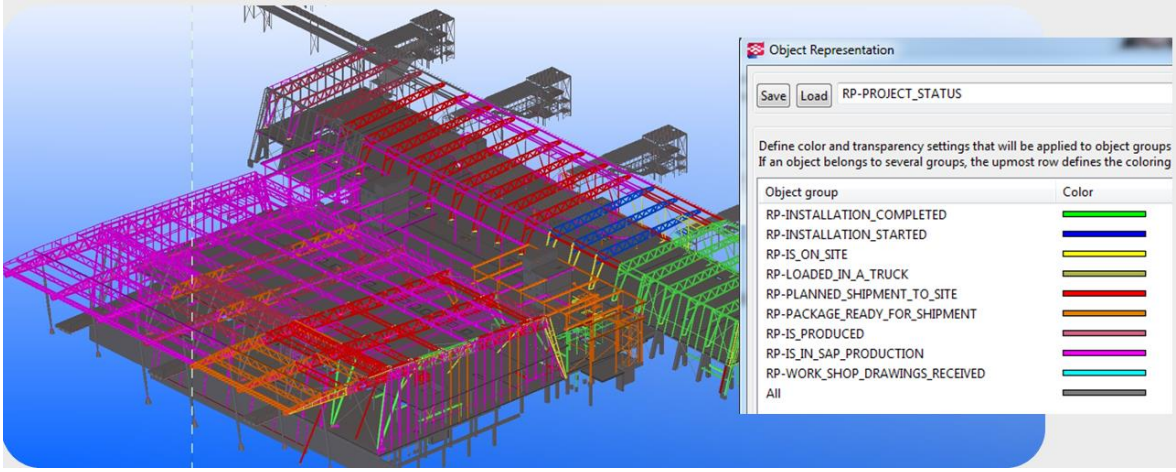

Figure 14 Tekla-Model showing the status of different elements

[55] Discussion 15.12.2017
[56] Discussion 24.11.2017

3.2 Detected problems and challenges

This chapter will mention problem and challenges that cause changes in schedules and plans. Everything mentioned in this section is based on interviews with managers and people with leading positions in Ruukki. Interviews were held with people from different departments to get different points of view. According to the discussions, Ruukki's own internal processes works quite well and late delivery is rare. The challenging part is to handle external factors causing disorder in timetables. In a factory where elements for ten different projects might be produced simultaneously, changes and disturbances in just one project might affect the whole production line.

In the subheadings below are answers from different departments listed. The answers are listed randomly and not by grade of importance.

3.2.1 Factory & production representatives[57] [58] [59] [60]

- ***Increased workload per element.*** Changes like added outfitting in elements may occur. In the offer phase the outfitting-rate per elements might be 10% to then later be realized that the actual rate is 15%. This means more resources must be put in for each workpiece in order to stay within the scheduled timeframe. The reason for this can be miscalculations during the offering phase or changes made by the customer.

- ***Data for work order late.*** The production planning is based on the work order (production lot). Material and shape-cuts are ordered based on these work orders. Work is also planned based on these. To make these work orders, the production planner needs sequence data from the site manager on the same time as they get the drawings due to pre-storage of elements between work orders. This enables them to add some labels to facilitate packing after painting.

- ***Factory receiving small drawing packages.*** When new drawings arrive, production must be planned again. If drawings arrive in small packages, planning must be done many times instead of receiving all drawings at once and planning everything once.

[57] Discussion 24.11.2017
[58] Discussion 27.11.2017
[59] Discussion 8.2.2018
[60] Discussion 13.2.2018

- ***Start of installation delayed***. Work and resources needed for each projects are allocated to get factory load and capacity on an even and manageable level. If installation is late then production might also be postponed which usually causes fluctuations in factory workload and forces factories to start running on uneven capacity. Resources reserved for the project might not be available later if production is postponed. If workload exceeds a factory's capacity, part of the work can be outsourced to subcontractors. Nowadays around 5000-6000 tons, almost as much as one factory's' yearly workload, is outsourced.

- ***Repacking***. When installation order changes on site, the sequences changes and trucks have to be repacked and planned again. This includes a lot of work as the packed elements are already in the sap-system and has to be taken out and put back in. This enables room for mistakes as these changes usually come with short notice and elements are needed on site urgently.

- ***Communication.*** The email correspondence is too comprehensive. Simply things that could be solved by a quick telephone call are being discussed in many emails. This is seen as a waste of time.

  Sometimes members from the project organization provide different information concerning same thing. This makes it hard to know who has the correct information.

- ***Lack of cooperation with site managers.*** People from factories not located in Finland, haven't met many site managers. Meetings between project managers and factory personnel happen more often. Meeting people in real life makes future collaboration easier.

- ***Few discussions with designers***. More discussions with designer would help the production planning.

- ***Language barrier.*** English language skill among team members can vary and misunderstandings have happened due to misinterpretation.

- ***Late information about transport.*** Shipment request are sometimes made to late (less than 1 week before shipment). Concerning big shipments and far distances (e.g. Northern parts of Norway), finding trucks and getting permissions can be challenging in only one week.

- ***Design is late***. If design is late, production is also late. If production can't meet delivery date, installation will suffer. The most common reason for delays are that the customer hasn't provided the designers with the initial data needed to start drawing. Without initial data designers can't proceed.

- ***Changes in design***. One typical example is shopping centres where some of the rooms and spaces that don't have a tenant in the offering phase, gets one during design or production, and then demands changes from the original drawings. Changes are a big challenge as they force production planners to redo all planning, without extra time and resources. In some plants, changes do occur frequently, which means there is no certain plan or schedule that is stable and without any changes.

- ***Raw material not available in time.*** Sometimes purchase of raw material can be done too late or with optimistic margins.

- ***Lack of planning.*** Wrong choices and lack of own planning can sometimes result in delays or uneven workload.

- ***Varieties in competence among managers.*** There are project managers that always succeed with finishing projects in time and within budget and there are also those who don't. Same goes for everyone in the project organization.

3.2.2 Business Area & Project management representatives[61] [62] [63]

- ***Postponed start of installation.*** In 80% of projects, installation start date is postponed by 2-4 weeks. Foundations aren't even cast sometimes when the first site delivery is planned, which means cancellation of cranes and work force, has to be carried out. This might cause a lot of extra costs as sometimes cranes, equipment and workforce might come from abroad or far away and have to be transported back or wait on site with costs still running.

- ***Last finishing in last minute.*** When projects are close to completion, small things are left undone. This doesn't occur in all projects but too often. They can be hard to get done in time and is left to the last minute. They're often not prioritized enough.

[61] Discussion 28.11.2017
[62] Discussion 15.12.2017
[63] Discussion 31.1.2018

- ***Lack of communication in project organization***. Poor communication between Project manager, factory and site is a common problem. Some say it's easier to communicate with site personnel than with the factory. Site activities are seen as more of a part of the project than factory activities. Keeping everyone updated with the latest information is sometimes left undone.

- ***Language barriers.*** Misunderstandings caused by language barriers can lead to wrong decisions and planning.

- ***Dedication.*** Everyone in project organization is not so committed to the project and lack of motivation creates bad atmosphere.

- "***My project"-thinking.*** Many project managers naturally only focus on their own project and do not consider other projects progress. One example of this is when a customer informs that the start of installation in a project is postponed by e.g. 2 weeks, whereupon the project manager keeps this information for himself to get two extra weeks in case of unexpected events. These two weeks could be valuable for other projects and factories as they could use the weeks to do better plans and to level out workload.

- ***Different experience and background***. Some project managers have experience and a background from the factory environment while others have gained their experience from working on site as site managers or foremen. This means they might have different views on how things should be done.

- ***Overload on factories.*** Sometimes many projects are under production on the same time which forces factories to exceed their capacity. This might result in lack of resources and outsourcing.

- ***Raw material not available.*** When there's a big demand for raw materials, delivery time from steel factories can be longer than usual, and orders have to be done earlier than normally.

- ***Lost "slot-time" in production.*** Each project has been reserved time needed in the production-lines, they're given an own so called "slot". If preceding work e.g. design or delivery of raw materials is late, it might postpone the start date of factory production. The time reserved for your project is then reduced, and in order to keep

to the schedule, adding resources is necessary and usually results in extra costs for all projects.

3.2.3 Design representatives[64] [65]

- ***Initial data.*** The design teams are prevented from starting when they're waiting for initial data from the customer. Sometimes production has started while designers are still waiting for initial data for the next block. This gives design teams less time to find optimal solutions for different elements.

- ***Unclear scope.*** This seems to be a very common problem. When a project has been sold and the deal is signed, what exactly has been sold still sometimes remains unclear for the project organization. This makes it hard for designers to know what to design. It might happen that more work is done than agreed on, which can be hard to the customer to pay for. Sometimes designers end up designing structures and elements that don't suit the business idea or production, and could rather be bought or out-sourced. Lack of clarity might end up in selling projects too cheaply.

- ***Communication.*** Conversations by telephone, online meetings and e-mails are the most common tools used. Explaining details and drawings is hard by e-mails and telephone, which is why meetings face-to-face are preferable. Language barriers can also cause problems.

- ***Keeping track of changes.*** When changes appear, they are usually agreed on by telephone, and are not documented. Sometimes it's hard to know what changes have been made, when they have been made and by whom. It's hard to get the customer to pay for non-documented changes.

- ***Project Organization.*** Roles and responsibilities are often unclear.

- ***Design is not prioritized enough.*** Not enough time. Well-made design makes all following phases like manufacturing, transportation and installation much easier. With unclear scope or a lot of changes, the amount of work might increase and design teams might run short on personnel.

[64] Discussion 15.1.2018
[65] Discussion, Project Pro Training 2017-2018

3.2.4 Site representatives[66] [67] [68]

- ***The main Contractor is late.*** In many cases the main contractor is not able to finish tasks, which in turn prevent installation to start or continue.

- ***Unclear project organisation.*** In bigger projects where many factories are involved, it sometimes remains undefined which persons are included in the project organization. This makes communication challenging as when you are e.g. ordering element transport from Oborniki in Poland, and don't know who to contact or who's responsible for production.

- ***No internal start-up meeting with the whole project organization.*** Having a face-to-face meeting where all could discuss the project and share opinions on how certain things can be done would make everyone more prepared for collaborating with each other. It's hard to know others views on risks and expectations for the projects without meeting them.

- ***Initial data and changes.*** Design hasn't received initial data needed to start drawing. Changes in design from original plans can cause corrections on site, which can be time and money consuming.

- ***Unclear content in contracts.*** Sometimes contracts aren't written clearly enough, which makes it hard to know what structures and elements that are included in the scope. Can result in additive costs if they're realized to be included in the scope, but not in the budget.

- ***Optimistic promises.*** Managers and others in the project organization may promise to deliver something in 3 weeks when the actual time required is 4 week.

- ***Misses in transportation.*** Getting the right elements to the site on the right time is crucial for the site activities to proceed. Some elements that are needed first might be incorrectly loaded and left behind. Transporting these elements can be expensive, depending on if there's enough time and space to add them to next shipment, or if they need to be shipped separately with an own truck. Ordering upcoming transport in order to get the missing elements is not always possible due to minimal space for storage on the site.

[66] Discussion 18.1.2018
[67] Discussion 15.12.2017
[68] Discussion, Installation Days 30.11-1.12.2018

- ***Misses from production.*** Misses that are made in the factory has to be fixed on site. Fixing things on site is more money- and time consuming than doing it in the factory. It can be small things like undrilled holes, wrong weld size, outfitting left undone etc. The element can also be hard to reach if it's already assembled on site, which results in the need for expensive lifts and cranes.

- ***Follow-up.*** When decisions from internal meetings have been made, well documented and detailed actions for what should be done, by whom and deadline for them should be defined. After delegating tasks e.g. checking upcoming element transport, the task should after completion be marked as "done or finished" in a document so others know that it's in order.

- ***Communication.*** Communication between everyone involved seems to be a common problem throughout the company.

4 Conclusions from analysis

4.1 Working procedures

In general, ways of planning and monitoring differs between managers and planners as people seem to have their own way of working. Some common tools and guidelines can be found, but usually the personnel make up their own documents and excel-sheets.

Factories seem to work in quite similar way as the procedures of LPS, according to progress monitoring. The production is however very vulnerable to changes in delivery sequence and design, which appear frequently.

4.2 Experience of LPS

From my own interviews with site managers from Ruukki, I found out that some of them had been involved in projects where the main contractor has been using Last Planner System. The name was however new to everyone I interviewed, and no introduction to the system had been held to sub-contractors. In some projects they weren't even invited to participate in the planning and no follow-up was done. LPS was in their opinion a very good system but only if the main contractor uses it properly and includes all parties involved in the planning. One site foreman said he had been working on a site where LPS was used, and that it was working very well. This was because the main contractor was competent using LPS.[69]

4.3 Most commonly recurring problems

After analysing all interviews, I noticed there are some problems that everyone mention which are continuously recurring. These are also the ones that cause most problems and cost a lot.

Regarding **external factors**, designers not receiving initial data and changes (in design, installation order etc.) from the customer, are serious and some of the most commonly recurring problems. These problems affect all processes within the project, and can also disturb other projects.

[69] Discussion 18.1.2018

Regarding **internal factors**, the biggest problem seem to be poor communication and sharing information.

These problems seem to be the root cause to many of the problems and challenges mentioned in the previous chapter.

A table over the problems can be found in **Appendix 1**.

5 Result

After learning the principles of LPS and finding out how people in Ruukki's internal organizations are working, I have come up with some conclusions regarding suitability and possible benefits.

5.1 General conclusions

According to studies over different companies' implementation of LPS, the system seems to have given valuable benefits for companies as it makes production plans more predictable and eliminates non-value adding processes. All activities are more controlled, and steering costs and resources are easier. Non-predictable production can lead to not so well-planned actions and improvisation. Improvisation entails higher risks, which can lead to additive costs or accidents.

After finding out how LPS works and where it is used, my main conclusion is that LPS works best for production planning and monitoring activities on building sites, in the environment for which it was designed. Direct connection to all on-going activities and quick face-to-face communication to all parties involved on site is essential when you have many workers, installation teams, lifts and cranes moving around and working in the same space. The system must be operated by the main contractor in order to get the system work properly, i.e. the system can't be led by sub-contractors as they're just responsible for their part of the project.

An eventual complete implementation of LPS in Ruukki's own project organization is in my opinion not necessary or even possible. There are many good things with LPS, but Ruukki's project organizations and production phases differ a bit from on-site production organizations. As Ruukki operate and has production facilities in many different countries, the project organizations are usually spread out and all parties (factories, design team, project engineers, installation team) might be located far away from each other. This makes daily and weekly face-to-face meetings and post-it scheduling challenging and in some cases not even possible.

5.2 Possible benefits and potential

5.2.1 Partial implementation

Even if reports and literature say that partial implementation is not optimal, I believe a partial implementation should be utilized, as Ruukki's different phases throughout projects differ from traditional on-site production (for which LPS is designed).

An own customised system or way of working, doesn't necessary have to carry the name "Last Planner System" or have any name at all, and some new tools could be designed based on principles and techniques from LPS. LPS could work well in planning and monitoring factory production and could eventually be implemented there. On the other hand, from what I've found out from my interviews, these things already work quite well and similar procedures as LPS are already in use (in the factories).

Utilising LPS principles and tools within the project organisation is something to strive for. Having weekly online meetings where all organization members are included, would facilitate problems with communication and give members possibility to share ideas and discuss issues.

5.2.2 Focus on people and visualization

LPS is based on collaboration and teamwork. This is essential in all businesses, and proper face-to-face kick-off meetings and weekly online meetings would enhance collaboration and information flow within project teams.

The psychological effects from committing something face-to-face are also something to consider when making different agreements. This is utilized in LPS where people are gathered in the same room for the Weekly Work Planning meetings.

Putting effort on making visual, uncomplicated, easy-understandable schedules is important to avoid mistakes and misinterpretations.

5.2.3 Increased safety and profit

According to the Danish contracting firm MT Højgaard, projects with LPS had 50% fewer accidents, and 40% fewer days of sick-leave than other projects. The projects with LPS also turned out to be 25% more profitable. These are remarkable numbers, which show that companies gain great benefits from implementing LPS.

5.3 Tools and appendices

As part of the result, I've created two excel-template proposals that can be used for look ahead planning on site. I've also created a proposal of an excel-template for schedules, an agenda for project weekly progress meetings and a template for the project organization matrix. All tools are based on the principles from Lean and LPS.

Based on the interview, I've created a list of the problems occurred. This list can be used for future development of different processes.

A snapshot of the different tools can be found as appendices in the end of the thesis.

Appendices:

1. Appendix 1: List of problems
2. Appendix 2: Weekly Work Progress -excel
3. Appendix 3: Preparation checklist (Look ahead plan)
4. Appendix 4: Constraint log (Look ahead plan)
5. Appendix 5: Project Organization Matrix
6. Appendix 6: Agenda for project weekly progress meeting

6 Suggestion for development

External problems are harder to resolve than internal ones. This doesn't mean they should be left unresolved, but by optimizing all internal processes, project organizations could act more proactively rather than reactively to the external issues. Listed below are some proposals that I think could enhance Ruukki's internal processes and communication within project organizations. The ideas in the proposals are based on Lean Construction and Last Planner System principles.

6.1 Start-up/kick-off meeting

Based on my interviews, this is a thing people really want. These are supposed to be held but in reality held partially without including everyone. A face-to-face kick-off meeting including everyone from the project organization, so that you could meet the people you're working with at least once and in that way improve communication within the organization. Here all risks can be gone through and clear targets can be set. This could work as the introduction to the upcoming weekly work planning meetings.

6.2 Weekly Work Planning (WWP) online-meetings

As communication is one of the main problems, ways to improve it in form of meetings seems to be welcomed.

These meetings would be held weekly, or less often in case of smaller project or less demanding project. The meeting would include everyone in the project organization and project progress would be gone through, quite accordingly to LPS-procedures.

The meeting would include a schedule briefing, an information check (ensuring everyone has the same information regarding sequence order, priority lists etc.), constraint analysis, PPC plus general things. It could also be commitment-based to get the psychological effect of promising something.

The project manager is leading the meeting and the meeting agenda in Appendix 6 is meant to be utilised here.

6.3 Training days

To level out the varieties in project result, common ways of steering projects could be used in order to get more predictable numbers. According to my interviews, project managers aren't annually gathered to discuss and share experiences like all the site personnel is during the "Installation Days". Some kind of "Project Management Days" should be held for project managers as well.

Also the idea of keeping the installation days in Oborniki plant in Poland seem to be warmly welcomed by site personnel and the people working in Oborniki. This could enhance the collaboration between site and factory as people get to meet their co-workers. Same goes for the Gargždai factory located in Lithuania.

6.4 Investigate usage of IFOA contracts (Allianssi-Malli)

As receiving initial data and continuous changes in design, are issues related to customer- or designer (if not "in-house" design) connections, this type of agreement could come in handy. Nowadays many big projects have been carried out successfully by using this agreement where risks and rewards are shared among the contractually bound partners (customer, designer, main-contractor and trade partners).

LPS usually works very well together with these kinds of agreements. Getting more predictability in design would facilitate planning and increase productivity in all following activities.

7 Conclusions and discussion

In this thesis I have investigated the potential benefits from implementing LPS. By comparing theory with the current methods of working I have managed to come up with the conclusion that a partial implementation and adapting essential principles from LPS would benefit Ruukki's operations.

By qualitative research methods in form of interviews, I've managed to expose some of the most commonly recurring problems that Ruukki Construction Building Systems is facing from start to end in projects. To get more answers, quantitative methods in form of questionnaires could have been sent out. On the other hand, I realized that same answers were recurring when interviewing different people, a questionnaire would therefore probably just have resulted in a lot of data with same content to go through.

I'm satisfied with my result, even if I had expected LPS to be more suitable to Ruukki's operations than it actually was. This thesis will also facilitate future development as recurring problems were detected and documented.

A challenging part was to go through the theory behind Lean Construction and LPS. Some authors are very clear with simple understandable text, and some have written books with a lot of text, where simple things are overanalyzed and taken out of context. In the end, I managed to find several well written and reliable references.

Due to the limits of the scope in this thesis, exact data regarding extra costs the problems are causing, have been excluded. Knowing what all these problems cost would be interesting, even if it is certain that they cause additive costs for projects. Knowing the numbers would probably motivate development of processes even more.

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http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Fatal_and_non-fatal_accidents_at_work_by_economic_activity,_EU-28,_2014_(%25_of_fatal_and_non-fatal_accidents)_YB16.png

Lean & Last Planner tools:
https://www.youtube.com/watch?v=mBh1A_Sc3rw
https://constructech.com/ourplan/

Thomassen Sander Barnes Nielsen (2003):
https://iglcstorage.blob.core.windows.net/papers/attachment-7a27d878-45c2-44fe-bc56-56d29be3dcf7.pdf

Ruukki Construction:
https://www.ruukki.com/gbr/b2b/this-is-us
intranet.ruukki.com

Interviews and meetings

Discussion 24.11.2017, Factory representatives (Finland), Online Meeting

Discussion 27.11.2017, Factory representatives (Finland), Online Meeting

Discussion 28.11.2017, Business area & Project management representatives (Finland), Online Meeting

Discussion 15.12.2017, Site- & Project managers (Finland), Vårdö Åland

Discussion 15.1.2018, Design representatives (Finland), Ruukki Office - Vaasa Finland

Discussion 18.1.2018, Site managers (Finland & Sweden), Online Meeting

Discussion 31.1.2018, Project manager (Finland), Online Meeting

Discussion 8.2.2018, Factory representatives (Poland), Online Meeting

Discussion 13.2.2018, Factory representative (Lithuania), Online Meeting

Courses & training

Lecture in Lean Construction, Novia Oct 2017, Anders Nordström Vison Oy

Installation Days Ruukki Construction Building Systems, Internal training for site managers and foremen, Vaskiluoto Vaasa 30.11-1.12.2018

ProjectPro, Internal training Ruukki Construction Building Systems, 2017-2018

Logistics 2017, Internal training Ruukki Construction Building Systems, Sep 2017

Table of Figures

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https://en.wikipedia.org/wiki/Lean_manufacturing

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https://www.5stoday.com/what-is-5s/

Figure 3:
Lecture in LC, Novia 2017

Figure 4:
http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Fatal_and_non-fatal_accidents_at_work_by_economic_activity,_EU-

Figure 5:
https://www.youtube.com/watch?v=3pmwaGuAQgM

Figure 6:
Porwal V., 2014, P. 8

Figure 7:

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Mossman A., 2013, P. 15

Figure 9:

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Figure 10:

Mossman A., 2013, P. 16

Figur 11:

http://enewsletters.constructionexec.com/techtrends/2016/04/if-you-can-see-it-you-can-manage-it/

Figure 12:

Own figure

Figure 13:

Logistic 2017, Internal Training Ruukki

Figure 14:

Logistic 2017, Internal Training Ruukki

Appendix 1 List of problems

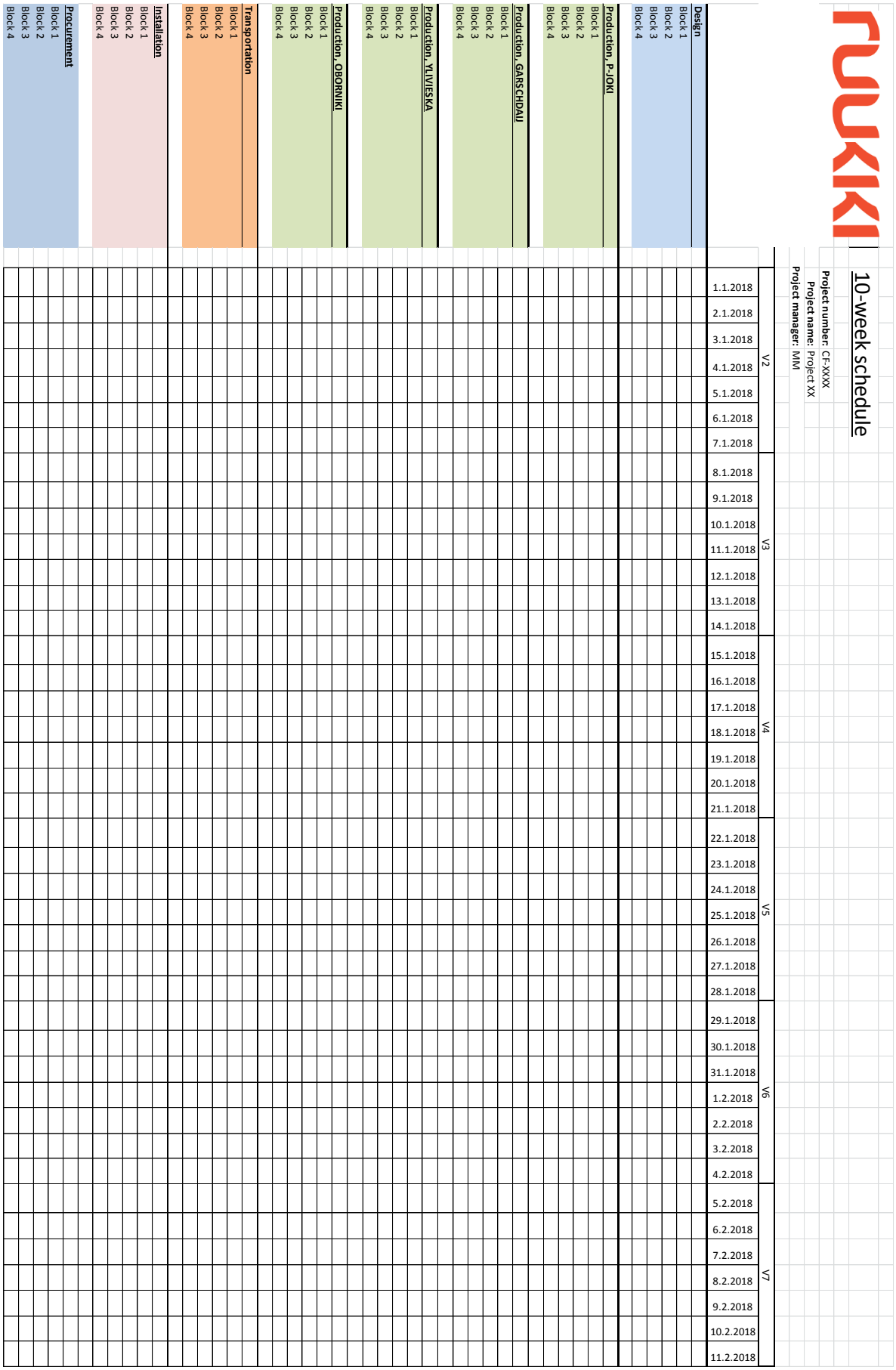
Detected problems based on interviews

Author: Victor Westö
Year: 2018
Reference: Thesis: Last Planner System

				Causes	
Department	**Problem**	**Explanation**	**Cause**	**Internal**	**External**
Factory:	Increased work per element	More work put in than originally	Changes from customer/design		X
	Data for work order late	Prevents planning of production	late information	X	X
	Fluctuations in factory capacity	Forced to use more resources than planned	changes in projects, delays, misses,	X	X
	Repacking	Repacking shipments to site.	Changes on site, change in sequence order	X	X
	Poor communication	Not enough discussions with site managerrs and design managers. Too much e-mail correspondence about simple	Routines, bad habits	X	
	Design is late	Drawings not received in time	Initial data not received from customer		X
	Changes in design	Requires changes in production--> replanning	Customer demands		X
	Language barriers	Causes misunderstandings	Lack in language skills	X	
	Late shipping information	Late shipping information from site	informing 1 week before is not enough	X	
	Raw material not available	-	Big demand, not ordered in time	X	X
	Varience in competence among personnel	-	Lack of experience, lack of training	X	
	Delays on site not informed to factory	Project manager not informing factory if delays occur on site --> elements must be stored on factory (some factories don't have enough space for storage). Factories could focus on more urgent projects.	Bad information flow. Not informing	X	
	Receiving small drawing packages often	Production has to be replanned when new drawings arrive. Sometimes couple of times per	Small drawing packages arriving simultaneously (due to changes)	X	X
Project management:	Postponed start of installation	Causes replanning of everything	Main contractor late (or changes on site)		X
	Last finishing late	In end of projects, small thing left undone or forgotten (not prioritized enough)	Not prioritized enough	X	X
	Poor communication	Information flow between members in the project organization not working properly	Routines, way of working	X	
	Language barriers	Causes misunderstandings	Lack in language skills	X	X
	No dedication	Lack of motivation	Bad relations, bad management etc.	X	X
	"My-project"-thinking	Project manager just focus only on the own projects outcome. Doesn't care aobut other projects.	Tunnel-vision	X	
	Different experience	Some managers have gained expreince from site, some from factory. Can mean different views on things.	Different experience	X	
	Factory overload	Factory running on overcapacity	Added work to elements. Changes from customer. Many on-going projects.	X	X
	Lost "slot-time" in factory production	Production prevented from starting and projects loose time reserved for production.	Initial data not received from customer. Predecessing projects not finished yet.	X	X
Design:	Initialdata missing	Design can't do anything without the initial data from the customer.	Initial data not received from customer		X
	Unclear scope	Sometimes unclear what has been sold. Content in contract may be diffuse.	Unclear contracts.	X	
	Communication	Design details are hardly explained through e-mails. Getting information from customer is challenging.	Not enough meeting (online & f2f)	X	X
	Keeping track on changes	Changes often agreed on on telephone. Hard to know what's a change.	Lack of time documenting changes.	X	

	Project organization unclear	Sometimes hard to know who's part of the project. Also customers contact persons.	Bad information flow	X	X
	Design not prioritized enough	Well-planned design that would facilitate production and installation not possible due to lack of time for design.	Lack of time. Not prioritized enough.	X	X
Installation:	Main contractor late	Installation teams prevented from starting or continue next phase.	Customer is late		X
	Project organization unclear	Sometimes hard to know who's part of the project. Also customers contact persons.	Bad information flow	X	X
	No proper start-up meetings	A common start-up meeting with everyone involved is sometimes missing.	Routines, way of working	X	
	Corrections on site	If changes in design appear and has to be corrected on site.	Changes/fails from customer		X
	Unclear content in contracts	Sometimes very diffused mentioned in contract what structure or element that belongs to the scope	Unclear contracts.	X	
	Optimistic promises	Managers promise something they can't hold.	Not enough informatin	X	X
	Misses in transportation	Elements packed wrongly and has to be stored on site.	Bad information flow	X	
	Misses in production	Misses that has to be corrected on site.	Misses in production	X	
	Follow-up	Follow-up from internal meeting and action plan missing.	Pour documentation. Routines. Bad habits	X	
	Communication	Poor communication within project organization.	Routines. Bad habits	X	

Appendix 2 Weekly Work Progress -excel



Appendix 3 Preparation checklist (Look ahead plan)

RUUKKI

Look Ahead Plan - Preparation Checklist

Project number: CF-XXXX
Name: Project XX
Phase/task: Installation Block 1

Author: MM
Date: 1.1.2018

No.	Task/activity	Drawings + Revisions	Shipment request	Contracts	Workforce	Sub-contractors	Cranes + lifts	Lifting plans	Equipment + spareparts	Material	Prior work ready	Safety	**Space** (cranes, storage, unloading trucks)	Deadline	Responsible person	Fixed	Status
1		X	X	X	X	X	X	X	X	X	X	X	X	31.3.2018	MM	31.3.2018	OK
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3																	
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Appendix 4 Constraint log (Look ahead plan)

RUUKKI

Look ahead plan - Constraint log

Project number: CF-XXXX
Name: Project XX
Phase/task: Installation Block 1, Seq A

Author: MM
Date: 1.1.2018

: Days before deadline = 5
: Deadline exceeded

No.	Name of Constraint	Explanation	Preventive actions	Responsible person	Deadline	Comments	Fixed	Status
1	Broken equipment	Several tools needed for next task are broken.	Send for repair. Order new ones.	Matti Meikäläinen	**23.2.2018**	New tools bought + spare parts bought.	**24.2.2018**	**OK**
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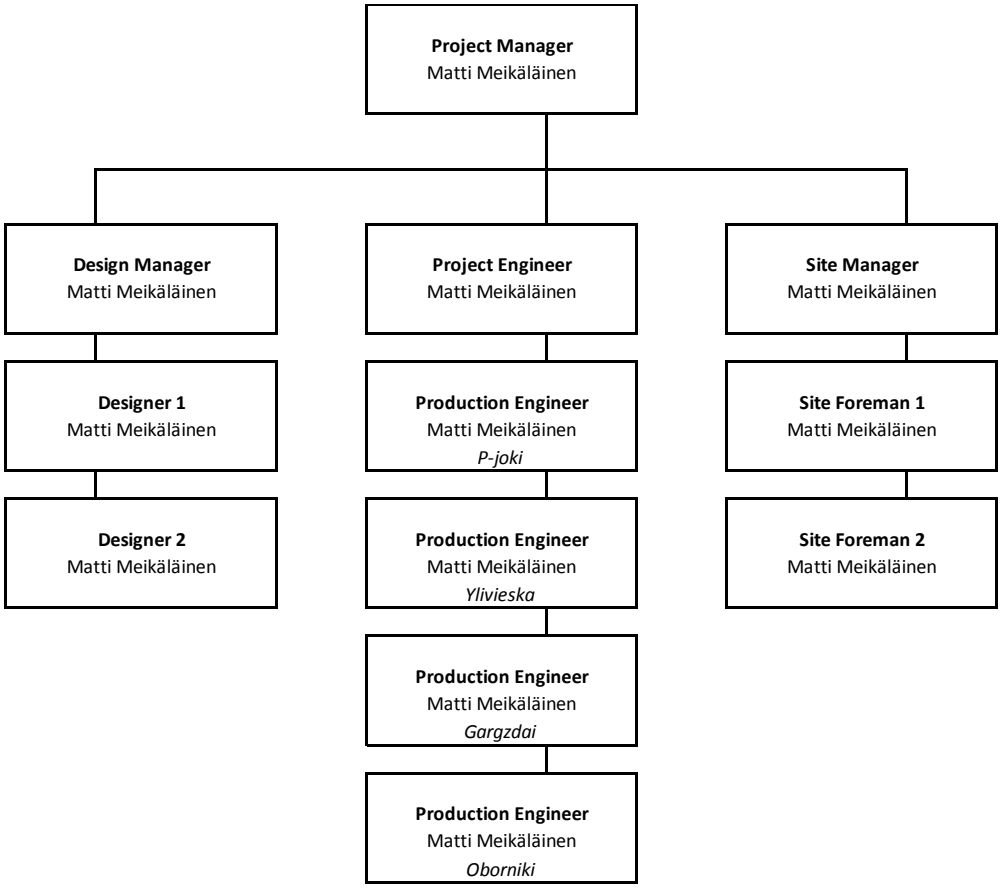
Appendix 5 Project Organization Matrix



Appendix 6 Agenda for project weekly progress meetings

RUUKKI
Building Systems

Agenda

Project Weekly Progress Meeting

Project:
Number:
Date:
Factories:

Meeting organizer & responsible:	**Name:**	**Present in the meeting:**
Project manager		
Required participants:		
Design manager		
Production engineer		
Site manager		
Production foreman, P-Joki		
Production foreman, Yka		
Production foreman, Obor.		
Production foreman, Garz.		

Building Systems

Agenda

1. **SAFETY**
   - Safety observations
   - Risks
2. **PROGRESS**
   - Design
   - Production
   - Installation
   - Total project
3. **PROJECT PLANS**
   - Master schedule
   - Block division and **installation order**
   - Delivery Sequence **(shipping dates)**
   - Deadlines (information from site/production/design)
   - Project Organization
     - Organization Matrix
     - Changes and contact information
4. **LOOK AHEAD PLANNING**
   - Ensuring pre-conditions
   - Learning from previous breakdowns (PPC)
   - Commitment to weekly plan (plan agreed on between meeting attendees)
5. **CONSTRAINTS** (CONSTRAINT LOG)
   - Briefing of project related constraints and challenges
   - Root cause to constraints
6. **QUALITY**
   - Non Conformity Reports
7. **OTHER ISSUES**
   - -